

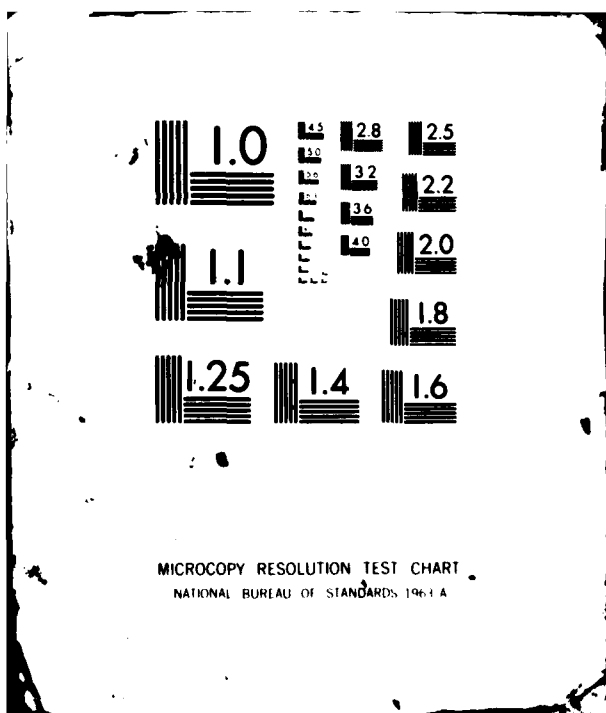
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ACCIDENTAL INJURIES AMONG NAVAL PERSONNEL BY OCCUPATION, DUTY STATUS, AND PAY GRADE

J. C. FERGUSON
M. S. McNALLY
R. F. BOOTH

REPORT NO. 81-7

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Accidental Injuries among Naval Personnel by
Occupation, Duty Status, and Pay Grade

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From the Environmental Medicine Department

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Background

Accidental injuries account for almost 25% of all deaths and disabilities in the United States. In order to provide more effective occupational safety and health programs, it is necessary to understand the role of occupational and environmental factors contributing to accidents in the Navy.

Objectives

The objective of this study was to determine the extent to which these factors contributed to occupational accidental injuries: naval occupation, location at the time of injury (on or off the job), and level of responsibility.

Approach

The study included all naval hospitalization attributable to occupational injuries of all Navy personnel occurring in all 50 occupations during the period 1974-1976 (N = 20,720). Occupation, pay grade, primary assignment, and duty status code (on-duty, off-duty, or duty status unknown) were extracted from each patient's hospitalization record. Injury rates for each occupation and duty status were compared to those for all occupations combined.

Results

Twelve "blue-collar," predominantly sea-going or construction occupations, were significantly higher than the Navy injury rate norm and 24 "white-collar" occupations, typically in clerical, supply, administrative, or technical assignments, were significantly lower than the Navy norm. Occupations with high on-duty injury rates tended to have high off-duty rates as well. An inverse linear relationship was found between injury rate and job responsibility for all occupations combined.

Conclusions

Risks of accidental injury vary widely among naval personnel as a function of occupational assignment and job status, but a relatively small number of sea-going and construction jobs were found to be significantly higher than the Navy norm. The positive, relatively high correlation (.70) between on- and off-duty injury rates suggests common personal attributes, such as risk-taking attitudes, operating in both settings. Although all occupations showed the same inverse linear relationship between injury rate and seniority, the slope of this curve varied considerably, suggesting that experience and familiarity with the work environment and not seniority alone led to the reduction in injury rate. Training level and ratio of rated to un-rated personnel also were found to be significant in the relationship of seniority to injury rates.

Recommendations

Occupations and pay grades with greater injury rates should be given priority in safety and health training efforts. A multi-pronged approach must be used to reduce the occurrence of occupational accidents. Safety training should include the role of specific occupational factors.

Accidental Injuries among Naval Personnel by
Occupation, Duty Status, and Pay Grade

One of the costliest and most pervasive problems in industry is that of industrial accidents. Yet, little systematic research has been conducted in this field, and surprisingly meager factual data are available to guide preventive efforts. Large military organizations, such as the Navy, with relatively complete and accurate records of more serious injuries may provide useful data concerning the incidence and principal causal factors involved in accidents; some of these relationships might be generalizable to civilian industry.

Accidental injuries accounted for almost 25% of all days lost because of hospitalizations for Navy enlisted personnel, or almost one-half million noneffective days, in 1974 (1). The cost to the U.S. Government in terms of dollars and manpower wastage, together with the associated human suffering, provides a strong incentive to reduce injury rates. An understanding of important occupational factors contributing to naval accidents should make possible more effective accident prevention programs.

Previous research has reported that accident rates vary with occupation (2,3) and division or type of work assignment aboard ship (4,5). Brownley (2) reported that the occupational specialties of Engineman, Boatswain's Mate, Hull Maintenance Technician, Gunner's Mate, and Boiler Technician had significantly higher accident rates than other occupations aboard ship. Gunderson (4) found that Boiler, Machinery, and Deck divisions aboard ship not only had hazardous work environments but unfavorable work climates as well; that is, members of these divisions not only described their work spaces as hot, dirty, noisy, and unsafe but also reported low work group cooperation. It is not surprising then that several of the shipboard occupations reported by Brownley to have high accident rates normally work in divisions that were identified by Gunderson as the most hazardous.

Previous research also has shown that accident rates in the Navy generally decreased with increasing levels of responsibility and job experience (2,3,5,6). However, this relationship between seniority and accident risk has not been examined within particular occupational fields. In this study occupations were clustered into functionally similar fields, and accidental injury rates were compared for three levels of seniority as defined by pay grade: Apprentices or nonrated personnel (E-1 through E-3), journeymen or petty officers (E-4 through E-6), and supervisors or chief petty officers (E-7 through E-9).

Job demands, work activities, and environmental exposures presumably vary widely as a function of Navy occupation and level of responsibility or seniority. It would be of interest to determine if such variations are associated with differences in injury risks. Other factors outside the sailor's work environment, such as types of recreational pursuits, drinking behavior, and motor vehicle driving habits, also affect accident rates. The complete medical care provided by the U.S. Navy insures that a large proportion of injuries occurring off the job are treated at naval facilities. The availability of these records makes it possible to compare the incidence of off-duty and on-duty injuries. Brownley (2) analyzed major accidents by duty status and determined that 52% of the accidents in his sample occurred off duty. An earlier study by the present authors (7) indicated that 58% of accidental injuries resulting in hospitalization during 1974-1978 occurred off duty, 21% occurred on duty, and 20% were unspecified as to duty status.

Accident prevention or safety thus must be viewed as more than an engineering problem; it involves the study of attitudes and behavior that contribute to accidents both at work and at play as well as occupational factors that lead to hazardous exposures. In the present study three major occupational factors are examined: occupation, location (on the job/off the job), and level of experience or responsibility.

METHOD

The study included all admissions for male Navy enlisted personnel in designated occupational specialties who were

hospitalized for accidental injuries in naval medical facilities during the period 1974-1978 (N = 22,728). General duty enlistees (personnel in pay grades E-1 through E-3 who had not entered a particular occupation) were excluded. Hospitalization data were obtained from computer files maintained at the Naval Medical Data Services Center, Bethesda, Maryland. These records were edited and incorporated into the medical history files maintained at the Naval Health Research Center, San Diego, for all active duty naval personnel. Occupation, pay grade, primary diagnosis, and duty status code (on-duty, off-duty, duty status unknown) were extracted from each patient's hospitalization record. Hospitalizations were considered due to injury if the diagnoses were included in the "Accidents, Poisonings, and Violence" category of the International Classification of Disease, Adapted for Use in the United States, Eighth Revision. Injuries were not included that were self-inflicted, combat-related, or the result of an assault.

The average number of active duty personnel at risk in each occupation was determined from quarterly reports published in Navy and Marine Corps Personnel Statistics (NAVPERS 15658). Injury rates for individual occupations were compared with Navy norms (all occupations) by computing the percent of expected--an index based upon the ratio of the observed or actual number of injuries for a given occupation to the expected number of injuries for that occupation. This index is very similar to the statistic relative risk but differs slightly in the method of computation. The expected number of injuries was computed by the following formula:

Expected number of injuries in Occupation A =

$$\frac{\text{Number of men in Occupation A}}{\text{Number of men in all occupations combined}} \times \text{Number of injuries in all occupations combined}$$

Similarly, the expected number of injuries on duty (or off duty) for a given occupation can be computed by the formula:

Expected number of on-duty injuries in Occupation A =

$$\frac{\text{Number of men in Occupation A}}{\text{Number of men in all occupations combined}} \times \text{Number of on-duty injuries in all occupations combined}$$

The expected number of injuries for a specific group, such as chief petty Officers (CPOs), petty officers, or nonrated personnel, in a given occupational field can be computed by the following formula:

Expected number of injuries among CPOs in Occupation A =

$$\frac{\text{Number of CPOs in Occupation A}}{\text{Number of CPOs in all occupations combined}} \times \text{Number of injuries among CPOs in all occupations combined}$$

The percent of expected injuries for each comparison was computed by the formula:

$$\frac{\text{Observed number of injuries for Occupation A}}{\text{Expected number of injuries for Occupation A}} \times 100 = \text{Percent of expected injuries for Occupation A}$$

The percent of expected then expresses the relationship of injury rate in a particular occupation to that in all occupations combined (the Navy norm): For example, 100% of expected indicates that the injury rate in the particular occupation is the same as that in the whole Navy, and 200% of expected indicates that the injury rate for an occupation is double that for the Navy generally.

The chi-square statistic was used to determine the significance of differences between observed and expected frequencies of injury.

RESULTS

Occupation and Accidents

Table 1 presents the occupations with total accidental injury rates significantly higher or lower ($p < .05$) than the Navy-wide norm. These occupations are listed by occupational field, grouped by functional similarity. The number of occupations comprising the field are in parentheses.

Table 1

Occupations with Total Accidental Injury Rates Significantly Different from the Navy-Wide Norm
Grouped by Occupational Field^a

<u>Higher than the Navy-Wide Norm</u>	<u>Lower than the Navy-Wide Norm</u>
<u>General Seamanship:</u> (2 Occupations)	<u>Sensor Operations:</u> (3 Occupations)
Boatswain's Mate	Ocean Systems Technician
<u>Ordnance Systems:</u> (4 Occupations)	<u>Weapons Control:</u> (2 Occupations)
Mineman	Fire Control Technician, Electronics Technician
<u>Marine Engineering:</u> (4 Occupations)	<u>Communications:</u> (3 Occupations)
Machinist's Mate, Engineman, Boiler Technician	Radioman, Cryptologic Technician
<u>Health Care:</u> (2 Occupations)	<u>Data Systems:</u> (2 Occupations)
Hospital Corpsman	Data Systems Technician, Data Processing Technician
<u>Construction:</u> (7 Occupations)	<u>Administration:</u> (6 Occupations)
Equipment Operator/Equipmentman	Personnelman, Yeoman, Postal Clerk, Legalman, Navy Counselor
<u>Aviation Operations:</u> (7 Occupations)	<u>Logistics:</u> (4 Occupations)
Aviation Boatswain's Mate	Storekeeper, Disbursing Clerk, Mess Management Specialist, Ship's Serviceman
<u>Aviation Maintenance:</u> (6 Occupations)	<u>Media:</u> (5 Occupations)
Aviation Machinist's Mate, Aviation Structural Mechanic, Aviation Ordnanceman	Journalist, Musician
<u>Ship Maintenance:</u> (5 Occupations)	<u>Construction:</u> (7 Occupations)
Hull Maintenance Technician	Engineering Aid
	<u>Aviation Weapons Control:</u> (4 Occupations)
	Aviation Electronics Technician, Aviation ASW Technician, Aviation ASW Operator
	<u>Aviation Maintenance:</u> (6 Occupations)
	Aviation Maintenance Technician/Avionics Technician
	<u>Aviation Logistics Support:</u> (5 Occupations)
	Aerographer's Mate, Training Device Man, Aviation Storekeeper

^aOccupations constituting the entire occupational field are shown in Table 2.

Of the Navy-wide norm, 12 occupations had significantly higher total injury rates and 26 occupations had rates significantly lower. These results clearly indicate that accidental injuries differ markedly as a function of occupational assignment. The average percent of expected injuries for personnel in the 12 "high-risk" occupations was slightly more than twice the average for those in the 26 "low-risk" occupations. The highest percent of expected injuries for Boatswain's Mates (157%) was more than six times higher than that for Musicians, with the lowest percent of expected injuries. Three of four occupations in the marine engineering field had higher total rates than the Navy norm. All occupations in the weapons control, data systems, and logistic occupational fields, as well as five of six occupations in administration and three of four occupations in aviation weapons control had significantly lower injury rates than the Navy norm.

Duty Status and Accidents

Comparisons of accidental injuries by duty status (on-duty or off-duty) are shown in Table 2 for each Navy occupation,

again segregated into occupational fields. "Sea-going" occupations (Boatswain's Mate, Gunner's Mate, Electrician's Mate, Hull Maintenance Technician, and all occupations in the marine engineering field) had more hospitalizations for on-duty injuries than would be expected based upon Navy-wide norms. Also construction occupations (Construction Electrician and Equipment Operator), Aviation Boatswain's Mate, and Hospital Corpsman had many more on-the-job injuries than expected.

Table 2
Accidental Injuries by Occupational Specialty and Duty Status

Occupational Field and Specialty	Average Number on Duty ^a	On Duty			Off Duty		
		Expected	Actual ^b	Percent of Expected	Expected	Actual ^b	Percent of Expected
<u>General Seamanship:</u>							
Boatswain's Mate	8,493	87	180	207*	332	482	145*
Signalman	2,766	28	21	75	108	123	114
<u>Ship Operations:</u>							
Quartermaster	4,237	43	40	93	166	149	90
Operations Specialist	6,880	70	54	77	269	266	99
<u>Sensor Operations:</u>							
Electronics Warfare Specialist	1,540	16	11	69	60	48	80
Sonar Technician	5,922	61	49	80	231	221	96
Ocean Systems Technician	1,110	11	3	27**	43	25	67**
<u>Ordnance Systems:</u>							
Torpedoman's Mate	3,938	40	41	103	154	165	107
Gunner's Mate	6,610	68	101	149*	258	263	102
Missile Technician	1,410	14	8	57	55	64	116
Mineman	541	6	6	100	21	36	171*
<u>Weapons Control:</u>							
Fire Control Technician	8,129	83	56	67**	318	258	81**
Electronics Technician	17,243	177	85	48**	674	520	77**
<u>Communications:</u>							
Radioman	15,461	158	75	47**	604	541	90**
Cryptologic Technician	8,315	85	16	19**	325	218	67**
Intelligence Specialist	768	8	7	88	30	20	67
<u>Data Systems:</u>							
Data Systems Technician	1,781	18	6	33**	70	43	61**
Data Processing Technician	2,875	29	8	28**	112	63	56**
<u>Administration:</u>							
Personnelman	6,517	67	32	48**	225	179	70**
Yeoman	9,339	96	57	59**	365	255	70**
Postal Clerk	1,105	11	10	91	43	34	79
Legalman (E5-E9)	317	3	1	33	12	5	42**
Navy Counselor (E6-E9)	729	7	3	43	28	11	39**
Master-at-Arms (E6-E9)	561	6	5	83	22	18	82
<u>Logistics:</u>							
Storekeeper	8,858	91	77	85	346	267	77**
Disbursing Clerk	2,232	23	9	39**	87	37	43**
Mess Management Specialist	17,207	176	164	93	672	471	70**
Ship's Serviceman	4,670	48	37	77	182	146	80**

^aPersonnel strengths were averaged for calendar years 1974-1977 from quarterly tables in Navy Military Personnel Statistics (NAVPERS 15658).

^bNumber of admissions over the 4-year period.

* Significantly higher than expected; **significantly lower than expected.

Occupational Field and Specialty	Average Number on Duty	On Duty			Off Duty		
		Expected	Actual	Percent of Expected	Expected	Actual	Percent of Expected
<u>Media:</u>							
Journalist	664	7	3	43	26	14	54**
Lithographer	400	4	6	150	16	16	100
Illustrator/Draftsman	365	4	3	75	14	14	100
Musician	980	10	2	20**	38	11	29**
Photographer's Mate	2,009	21	16	76	78	68	87
<u>Marine Engineering:</u>							
Machinist's Mate	23,522	241	280	116*	919	1,046	114*
Engineman	8,648	89	135	152*	338	373	110
Machinery Repair	2,586	26	39	150*	101	98	97
Boiler Technician	10,965	112	205	183*	428	586	137*
<u>Health Care:</u>							
Hospital Corpsman	20,597	211	246	117*	805	1,189	148*
Dental Technician	3,040	31	27	87	119	100	84
<u>Construction:</u>							
Construction Mechanic	1,561	16	18	113	61	72	118
Builder	2,788	29	32	110	109	123	113
Steelworker	858	9	15	167	34	40	118
Utilitiesman	1,469	15	20	133	57	61	107
Construction Electrician	1,528	16	29	181*	60	56	93
Equipment Operator/Equipmentman	2,595	27	44	163*	101	144	143*
Engineering Aid	430	4	2	50	17	10	59
<u>Aviation Operations:</u>							
Aviation Boatswain's Mate	5,216	53	101	191*	204	251	123*
Aviation Support Equipment Technician	2,088	21	27	129	82	79	96
<u>Aviation Weapons Control:</u>							
Aviation Fire Control Technician	3,522	36	26	72	138	138	100
Aviation Electronics Technician	10,014	103	66	64**	391	343	88**
Aviation ASW Technician	1,824	19	11	58	71	57	80
Aviation ASW Operator	2,795	29	26	90	109	96	88
<u>Aviation Maintenance:</u>							
Aviation Maintenance Technician/ Avionics Technician (E-9)	583	6	2	33	23	13	57**
Aviation Machinist's Mate	13,173	135	150	111	515	602	117*
Aviation Electrician's Mate	7,616	78	77	99	298	280	94
Aviation Structural Mechanic	14,907	153	176	116	582	690	119*
Aviation Maintenance Administrator	2,761	28	14	50**	108	113	105
Aviation Ordnanceman	5,251	54	78	144*	205	252	123*
<u>Aviation Logistic Support:</u>							
Air Controlman	2,282	23	5	22**	89	87	98
Aerographer's Mate	1,559	16	5	31**	61	35	57**
Training Device Man	1,441	15	4	27**	56	42	75
Aviation Storekeeper	3,452	35	25	71	135	95	70**
Aircrew Survival Equipmentman	1,735	18	15	83	68	73	107
<u>Ship Maintenance:</u>							
Electrician's Mate	12,268	126	162	129*	479	462	96
Interior Communications Electrician	5,423	56	44	79	212	221	104
Hull Maintenance Technician	10,760	110	218	198*	420	528	126*
Pattern Maker/Molder	427	4	7	175	17	15	88
Precision Instrumentman/Instrumentman/ Opticalman	764	8	4	50	30	34	113

It can be seen that several occupations have significant deviations from the Navy norm for both on- and off-duty accidents. Indeed, the Pearson correlation between the incidence of on-duty and off-duty injuries over all 68 occupations was a relatively high .70 ($p < .05$).

Eight occupations (Boatswain's Mate, Machinist's Mate, Boiler Technician, Hull Maintenance Technician, Equipment Operator, Aviation Boatswain's Mate, Aviation Ordnanceman, and Hospital Corpsman) had higher injury rates than expected in both on-duty and off-duty status.

Those occupations with higher than expected injury rates tended to deviate farther from the Navy norm for on-duty accidents than for off-duty accidents, probably reflecting greater diversity and intensity of environmental stressors or hazards in the work place.

Seniority and Accidents

The importance of seniority on the incidence of accidental injury is shown in Figure 1. In analyzing the relationship between accidents and seniority, it was determined that the actual injury rate (number of injury-related hospital admissions per 100,000 strength per year) provided a clearer representation of the relationship than the percent of expected injury statistic. Figure 1 presents injury rates calculated across pay grade groups for four occupational fields with relatively high injury admission rates and two fields with relatively low injury admission rates, plus the admission rate for the total Navy.

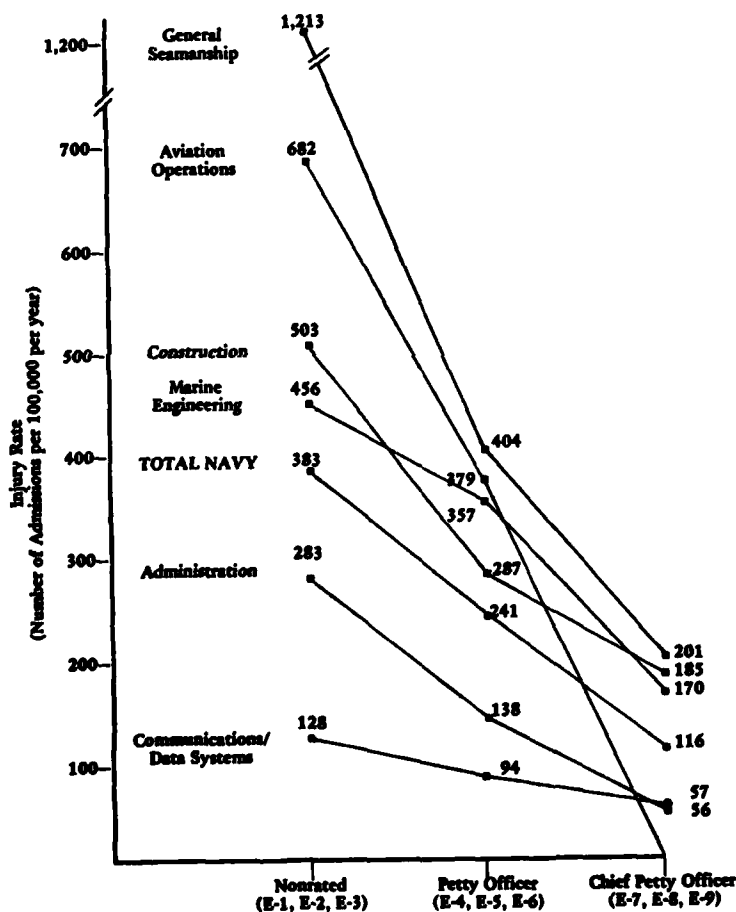


Fig. 1. Injury rates of selected naval occupational fields by level of seniority.

Figure 1 shows that for all occupations combined (Navy norm) there is an inverse linear relationship between injury rate and seniority. All of the occupational fields shown in Figure 1 have the same linear pattern, but the slope of the curve varies considerably as a function of the degree of hazard associated with the occupation. Minor variations in the general pattern probably reflect working conditions in particular occupations. For example, marine engineering petty officers do not show as large a reduction in rate compared to nonrated personnel in their field as construction petty officers do. This suggests that experience and familiarity with the work environment does not moderate risk of injury to the same degree in all fields.

Two other factors that could have contributed to the relationship of seniority to injury rates are manning level and ratio of rated to nonrated personnel. Undermanning could force all personnel to work longer hours and thus force supervisory personnel to spend more time doing work that should be done by subordinates. The midyear manning levels (number present/number authorized X 100) for petty officers (pay grades E-4 through E-6) in occupational fields that were consistently high or low in injury rates were averaged during the period 1974-1977. The percentages of manning for general seaman-ship, marine engineering, and ship maintenance (high injury rate) were 83.2%, 87.4%, and 85.5%, respectively, compared to manning levels of 102.5%, 93.7%, and 90.0% for weapons control, logistics, and aviation logistics support, respectively.

A second organizational factor that could affect accident rates is the number of supervisory personnel in relation to inexperienced apprentices. This factor is often related to manning level, but it can be measured as a separate concept. In the present instance, the proportion of personnel in an occupation who were nonrated was used as an index of supervisory control. When occupational fields were dichotomized on the two variables of proportion nonrated and injury rate, a significant relationship emerged ($\chi^2 = 5.56$, $p < .05$). Occupational fields with low proportions of nonrated personnel tended to have low injury rates at all levels of seniority, and occupational fields with high proportions of nonrated personnel had high injury rates at all levels of seniority.

DISCUSSION

Our results indicated that risks of injury varied widely among naval personnel as a function of occupational assignment and pay grade. Occupations with the highest on-the-job injury rates were predominantly sea-going or construction specialties. Personnel in these occupations typically perform physical work aboard ship with or near heavy machinery, propulsion plants, machine tools, cargo, and ordnance.

The Hospital Corpsman specialty was an exception to this generalization, and it is perhaps surprising that this occupation had a slightly higher injury rate on the job than Machinist's Mates. A possible cause for the high accident rate is that Corpsmen have more diverse types of assignments and environmental exposures than any other Navy occupation. In addition to serving in hospitals, dispensaries, and clinics, Corpsmen serve with aviation squadrons and diving units as well as aboard ships and with the Marine Corps.

On-duty accident results were in general agreement with those reported by Brownley (2) who identified nine of the 13 occupations found in the present study to have above average risks of injury on duty. Brownley did not cite four occupations found here to have risks significantly above the Navy norm: Machinery Repairman, Aviation Boatswain's Mate, Aviation Ordnanceman, and Hospital Corpsman. The 13 occupations identified in this study as high-risk (i.e., above the Navy norm) comprise approximately one-third (34.6%) of the Navy enlisted population but account for slightly more than one-half (51.5%) of all serious on-duty injuries.

It seems clear that these results provide a rational basis for accident prevention strategies; the occupations with greatest injury risks should constitute priority targets for prevention and control efforts.

The positive and relatively high correlation noted between on- and off-duty injury rates is one of the most interesting results, suggesting common personal attributes operating in both settings. For example, one explanation might be the risk-taking attitudes are manifested both on the job and off duty in members of certain occupations. Levine et

al (8) developed a scale measuring attitudes toward risk taking aboard an aircraft carrier and found that this scale correlated significantly with accidents in both enlisted air wing personnel and aviators. The scale described "an individual who says he chooses and enjoys activities which he perceives to be risky. This behavior is different from being unable to distinguish dangerous situations from those that are safe" (p. 84). Although Levine studied only on-duty accidents, such risk-taking attitudes appear to apply to off-duty behavior as well. Further studies measuring risk-taking behavior in both settings are needed to confirm this hypothesis.

Although injury rates generally decreased with experience or seniority, they remained higher in certain occupations than others, regardless of seniority. Part of the reason for this obviously relates to the inherent riskiness of certain work environments, such as the engine room of a ship, and the exposure of personnel at all pay grade levels to these environments.

The gross statistics used to analyze manning levels and proportion of supervisory personnel supported the possibility that these factors also contributed to the relationship of seniority to injury rates, especially for higher pay grades. It has been suggested by Dean and his associates (9) that manpower utilization as well as manning level may be a factor in predicting injury rates aboard ship.

Our results clearly illustrate that a multivariate approach must be used to explain the differences in occupational risks and injury rates. A primary goal of future studies will be to provide more definitive explanatory principles, including the role of individual differences, in understanding and preventing accidental injuries.

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18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Accidents Hospitalizations Occupations Naval personnel		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The relative incidence of accidental injury for Navy enlisted men during 1974 through 1977 was analyzed for 68 occupations, three pay grade or job responsibility levels, and duty status (on or off duty) at the time of the injury. Twelve "blue-collar," predominantly sea-going or construction occupations, were significantly higher than the Navy injury rate norm and 24 "white-collar" occupations, typically in clerical, supply, administrative, or technical specialties, were significantly lower than the Navy norm. An inverse linear relationship was found between injury rate and job responsibility for all occupa-		

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tions combined. This relationship varied by occupation, however, suggesting that experience and familiarity with the work environment may not moderate risks to the same degree in all occupational fields. Occupations with high on-duty injury rates tended to have high off-duty rates as well, suggesting at least some common causal factors.

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